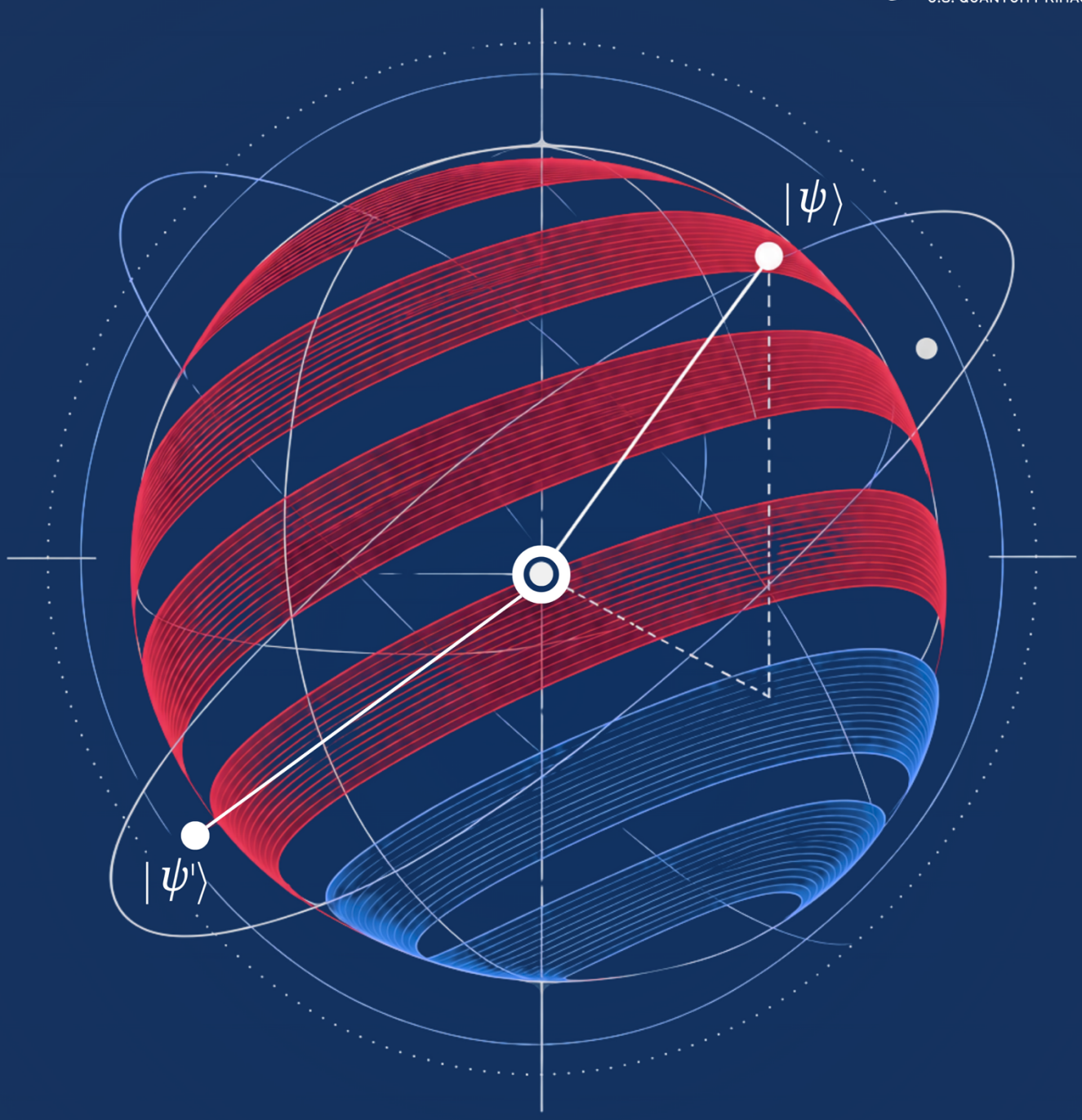
COMMISSION ON
U.S. QUANTUM PRIMACY



DEFINING THE AMERICAN QUANTUM ERA

A Preliminary Report by the Commission on U.S. Quantum Primacy

NOVEMBER 2026

COMMISSION ON
U.S. QUANTUM PRIMACY

November 10, 2026

Quantum technologies have the potential to reshape how nations compute, sense, communicate, and exercise national power. These technologies are advancing at different speeds, with applications in sensing and navigation arriving today and potentially transformative capabilities in computing and networking on the horizon. The full economic and national security effects of quantum technologies remain uncertain. The need to prepare for their benefits and risks, however, is becoming increasingly clear. These opportunities warrant sustained federal investment and coordination to help industry, universities, and the national laboratories turn quantum discoveries into useful capabilities.

The United States enters the quantum era from a position of strength, built on decades of research, world-class institutions, and private-sector innovation. But scientific leadership alone will not be enough. Leadership will belong to the nations that translate advances in quantum information science and engineering into capabilities that strengthen national security, technological leadership, and economic power. Other nations are working to build these capabilities as well, making the choices we make today consequential for America's future.

This is the challenge the Commission on U.S. Quantum Primacy was convened to address. This preliminary report identifies four elements that must advance together: discovery, development, deployment, and scaling. It outlines near-term priorities for sustaining America's scientific edge while building the capabilities needed to turn innovation into real-world advantage.

We extend our gratitude to the Commissioners for proposing strategies to help ensure that America develops the capabilities, industries, and partnerships needed to shape the quantum era.

Sincerely,

Todd Young
U.S. Senator (R-IN)

Ben Ray Luján
U.S. Senator (D-NM)

Ylli Bajraktari
President, Special Competitive Studies Project

About the Commission

Mission

The Commission on U.S. Quantum Primacy (CUSP), convened by the Special Competitive Studies Project (SCSP), is dedicated to ensuring that the emergence and diffusion of quantum technologies strengthen U.S. national power, driving our national security, technological transformation, and economic might.

Commission Leadership

Senator Todd Young (R-IN), *Co-Chair*
Senator Ben Ray Luján (D-NM), *Co-Chair*
Ylli Bajraktari, President of SCSP, *Co-Chair*

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Key Deliverables

- *Preliminary Report (Fall 2026):* A strategy argument for quantum, emphasizing its role in ensuring U.S. national security, economic stability, and technological leadership, with initial recommendations of near-term priorities.
- *Final Report (Spring 2027):* A plan for achieving U.S. quantum primacy, including policy recommendations, infrastructure needs, and strategies to accelerate quantum technologies.

Scope of Work

The Commission's activities include: plenary sessions of Commissioners and co-chairs, and three commission working groups focused on (1) infrastructure, (2) informatics, and (3) integration.

The Commission convened its first plenary in March of 2026 on Capitol Hill in Washington, D.C., followed by working group meetings at SCSP offices, with Commissioners receiving informative briefings from outside experts. The Commission's second plenary was held in September 2026 at Sandia National Laboratories in Albuquerque, New Mexico. These conversations shaped this preliminary report and will drive the recommendations in the final report, to be presented in Spring 2027.

About the Preliminary Report

This report is intended to inform policymakers, industry leaders, researchers, and other stakeholders working to advance U.S. leadership in quantum technologies. It seeks to identify key challenges in the quantum ecosystem, outline near-term priorities for U.S. quantum competitiveness, and highlight areas where further coordination and action are needed.

The content in this report is partially derived from the Commission's working group meetings. It reflects the collective views and expertise of the Commissioners, with input from technical advisors, expert briefers, and Commission staff listed below. In developing this report, all Commissioners had the opportunity to review and provide feedback. The majority of Commissioners offered substantive input, which has been incorporated into this final version, and concurred with its release to the public.

Commission Co-Chairs Senator Young and Senator Luján provided guidance on developing this report but were not involved in formulating the specific policy recommendations. As co-chairs, the Senators provided strategic direction and supported the Commission's broader mission to advance U.S. leadership in quantum and technology competitiveness.

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The Challenge Before Us

Quantum technologies are expanding the frontiers of computation, measurement, and communication, creating capabilities with both significant economic impact and national security consequences. Recognizing this potential, nations around the world are advancing national strategies to strengthen their quantum capabilities, intensifying global competition for leadership in these technologies. China, in particular, has made quantum technologies a strategic priority, pursuing significant investments to advance its domestic capabilities.[1] To ensure the United States maintains a lead in quantum technologies, any cohesive national strategy must align ongoing federal initiatives and roadmaps while connecting scientific progress with industrial capacity, security, and adoption efforts.

This is easier said than done. Quantum is not arriving all at once or on the same timeline. Rather, quantum encompasses a variety of technologies, including quantum computing, quantum sensing, and quantum networking, each at different stages of maturity. Within quantum computing, for instance, multiple different architectures, known as "modalities," are being pursued, with no clear leading approach yet established.[2] Quantum sensing is further along, with advances in precision timing, magnetic field detection, and gravity measurement moving beyond the laboratory into applications in navigation, defense, and scientific discovery.[3] Although today's quantum computing systems face technical constraints like error rates and scale, they carry similarly transformative potential in chemistry, materials science, drug discovery, and other computationally demanding fields.[4]

Achieving such societal benefits simultaneously brings immediate consequences; just one fault-tolerant quantum computer could threaten some of the widely used cryptographic foundations that secure the modern world.[5] Networking that distributes entanglement among quantum computers and sensors remains a longer-term prospect. While early quantum communications systems and experimental networks exist today, the more consequential vision will require substantial advances in both hardware and infrastructure.[6] Together, these technologies represent not a single technological revolution on a fixed schedule, but a portfolio of emerging capabilities with the potential to reshape both national security and economic competitiveness as they mature at different speeds.

The pace and direction of this progress will also depend on how quantum technologies converge with other advances, particularly in artificial intelligence (AI). Exploring the ways in which both quantum and AI complement one another could accelerate progress in both fields.[7] For instance, AI can help accelerate

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[1] Marin Ivezic, China's 15th Five-Year Plan Makes Quantum an Industrial Imperative — Not Just a Research Priority, PostQuantum (2026).
[2] Marin Ivezic, Taxonomy of Quantum Computing: Modalities & Architectures, PostQuantum (2023).
[3] Quantum Sensing: From the Inner Workings of Cells to the Outer Limits of the Universe, U.S. National Science Foundation (2026).
[4] Quantum Computing Explained, NIST (last accessed 2026).
[5] Josh Schneider & Ian Smalley, What Is Quantum Computing?, IBM (2026).
[6] Incremental development and deployment of quantum networking are essential given the capital requirements and long timelines for infrastructure development. *See* Constanza M. Vidal Bustamante & Morgan Peirce, The Entanglement Edge: U.S. Strategic Priorities in Quantum Networking, Center for a New American Security (2026).
[7] Quantum AI: Harnessing the Power of Quantum Computing for AI, SCSP (2024)

quantum research through materials and device design, system control, and algorithm exploration.[8] AI has already proved to be transformational in the development of classical software, with real results in mathematics, and AI applied to quantum algorithm discovery and computational limit problems will be essential to the rapid advancement of capabilities.[9] Quantum computing may eventually contribute to selected AI workloads, such as generating training data through quantum simulation, although its practical value overall must be demonstrated against constantly improving classical approaches.[10] The countries that most effectively connect these two technological frontiers may be better positioned to translate advances into broader national capabilities.

The Geopolitical Stakes

A central strategic question is which nation can turn quantum advances into useful capabilities at scale and shape the terms on which those capabilities spread and are accessed. Leadership will depend on more than a single scientific breakthrough or technological first; it will require translating quantum information science, engineering, and technologies (QISET) into deployable systems and thriving industries, while shaping global markets, standards, supply chains, and security architectures. The stakes extend beyond the capabilities we can anticipate today. For the United States, sustaining leadership means enabling American scientists, engineers, and businesses to discover and harness capabilities we cannot yet anticipate—and creating conditions to translate those advances into enduring economic and national security advantages.

The United States enters this competition with major strengths in research, software, and private investment. U.S.-affiliated researchers account for 35% of the world's most-cited quantum papers, and, in December 2025 alone, U.S. software development kits were downloaded over 100 times more than Chinese alternatives.[11] However, America's position varies across quantum technologies and stages of commercialization, and leads in the laboratory do not automatically become leads in deployment or industrial scale. For example, in quantum computing, estimates for 2025 identified approximately 39 to 73 deployed U.S. machines, compared to 15 to 18 Chinese systems.[12] Yet, China is moving to make its

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[8] Yuri Alexeev, et al., Artificial Intelligence for Quantum Computing, Nature Communications (2025); Discovering Quantum Algorithms with AI, U.S. Department of Energy (last accessed 2026); Designing More Efficient Quantum Circuits with Claude, Anthropic (2026).

[9] Giorgio Amasanti & Jasmin Jahic, The Impact of AI-Generated Solutions on Software Architecture and Productivity: Results from a Survey Study, arXiv (2025); Cade Metz, After Reinventing Mathematics, Can A.I. Eradicate Computer Bugs?, New York Times (2026); Ten Advances in Mathematics and Theoretical Computer Science, OpenAI (2026); Designing More Efficient Quantum Circuits with Claude, Anthropic (2026).

[10] AI is constantly raising the bar for utility-scale quantum computers, as applications once previously thought to have a quantum advantage could now be carried out due to advancements in AI and classical computing. *See* Michael Schirber, A Moving Target for Quantum Advantage, APS Physics (2024); Ryan LaRose, A Brief History of Quantum vs Classical Computational Advantage, arXiv (2026); Victor Gaspar & Katsuyuki Hanai, How Quantum Technologies could Open New Frontiers for AI, OECD (2026); Quantum Computing and Artificial Intelligence Use Cases, QED-C (2025).

[11] Quantifying the Competition: Assessing Leadership in Quantum Technologies, Special Competitive Studies Project (2026).

[12] How Many Quantum Computers Are There in the World? Estimates Suggest Over 100 in 2025, Quantum Zeitgeist (2025); Brian N. Siegelwax, China's Mightiest Quantum Computers, Quantum Dragon (2025); Quantifying the Competition: Assessing Leadership in Quantum Technologies, Special Competitive Studies Project at 33 (2026).

hardware globally accessible: Origin Quantum's quantum computer that launched in May 2026 is available through the cloud, widening the pool of researchers and developers who can experiment on Chinese systems.[13] In quantum key distribution, a subset of quantum networking, China has moved from demonstration to infrastructure, with a national trunk line integrated into China Telecom's commercial fiber, while U.S. quantum networks remain predominantly regional testbeds.[14]

The bigger risk lies in manufacturing and the quantum supply chain. The United States still has access to critical inputs for quantum systems like helium-3 and specialized lasers, but Chinese cost and localization advantages could enable it to scale at a faster pace.[15] Chinese quantum firms are integrating cryogenics in-house after recent U.S. export controls, and China's domestic dilution refrigerator market grew roughly 58% from 2021 to 2025 against roughly 35% in the United States.[16] China is also building the cleanrooms that quantum hardware requires at roughly $150 per square foot, against $800 to $1,000 in the United States, lowering the barrier to manufacturing at scale.[17] China's supply chain edge complements its well-funded research and development (R&D) base: China allocates roughly $3 billion in public funding for quantum technologies per year compared to about $1 billion annually in U.S. federal R&D.[18] Together, these strengths allow China to adopt and scale innovation across the quantum technology stack faster than the United States can and underscore an immense strategic risk: American scientific strengths may not translate into leadership in deployment and industrial production. Therefore, the United States must be clear about what it is competing to achieve: quantum primacy.

[13] Mohib Ur Rehman, Origin Quantum Launches Wukong-180 Quantum System, Quantum Insider (2026); Marin Ivezic, Origin Quantum Computing Technology Co., PostQuantum (2026).
[14] Mohib Ur Rehman, Understanding Quantum Networking and Its Industrial Potential, Quantum Insider (2026); Hao-Ze Chen, et al., Implementation of Carrier-Grade Quantum Communication Networks Over 10000 km, npj Quantum Information (2025); Yilin Yang, et al., A 300-km Fully-Connected Quantum Secure Direct Communication Network, Science Bulletin (2025); Quantifying the Competition: Assessing Leadership in Quantum Technologies, Special Competitive Studies Project at 19-20 (2026).
[15] Quantifying the Competition: Assessing Leadership in Quantum Technologies, Special Competitive Studies Project (2026).
[16] Quantifying the Competition: Assessing Leadership in Quantum Technologies, Special Competitive Studies Project (2026).
[17] In the United States, lack of federal funding can impede cleanroom buildouts. *See* Semiconductor Fabrication Facilities Funded by the CHIPS Act: Project Status and Considerations for Congress, Congressional Research Service (2026); Quantifying the Competition: Assessing Leadership in Quantum Technologies, Special Competitive Studies Project at 22-23 (2026).
[18] Quantifying the Competition: Assessing Leadership in Quantum Technologies, Special Competitive Studies Project at 32 (2026).

What is Quantum Primacy?

> **Quantum primacy** is the enduring ability to discover, develop, deploy, and scale strategically consequential quantum capabilities and to use them to strengthen national security, technological innovation, and economic competitiveness.[19]

To date, many quantum milestones have rightfully been measured in technical and scientific terms. But national leadership requires a broader ambition: *quantum primacy—the ability to turn scientific advances into sustained strategic advantage across quantum technologies.* Quantum primacy should be measured through demonstrated capability, adoption, industrial capacity, and resilience, alongside continued scientific leadership, and the ability to shape the global quantum ecosystem through standards, partnerships, and technological influence.[20] It requires neither complete self-reliance nor being first at every milestone, but the capacity to establish and sustain advantages while drawing on the complementary strengths of trusted allies and partners.

Achieving quantum primacy therefore requires more than world-leading science and better machines. It requires a deep talent base and continuous foundational science to push the technological frontier; the engineering capacity to turn discoveries into reliable systems; the industrial base and infrastructure to manufacture them at scale; the software to make them useful; the standards to make them trustworthy; and the market demand and ability to integrate and deploy them across the economy and national security enterprise. Creating that demand requires greater attention to identifying and validating concrete end-use cases across quantum technologies to guide development toward practical needs and accelerate adoption. It also requires a network of allies and partners that expands markets, capabilities, talent, and trusted supply chains available to the United States.

The measure of quantum primacy will ultimately be not simply who produces the most publications, patents, or technological firsts, but who can convert quantum innovation into enduring deployment, scale, national power, and economic benefit. Nations that fall behind may become dependent on foreign suppliers and have less influence over standards, markets, and security requirements.

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[19] Quantum supremacy is a technical quantum computing concept that refers to the point at which a programmable quantum device performs a computation that is extremely difficult or impractical for a classical supercomputer to replicate, even if the computation has no practical application. Quantum advantage is another technical computing concept that refers to scenarios in which a quantum computer outperforms classical computers on a useful task. Quantum primacy, by contrast, is a broader strategic concept that encompasses the foundational capabilities necessary to achieve and sustain leadership in quantum technologies. Unlike quantum supremacy and quantum advantage, quantum primacy extends beyond quantum computing to include quantum sensing, networking, and the broader scientific, industrial, and technological ecosystem that supports their development and deployment. For more on "quantum supremacy" and "quantum advantage," *see* Marin Ivezic, Quantum Supremacy vs. Quantum Advantage, PostQuantum (2020).

[20] Metrics to measure quantum primacy could also include market share, speed of iteration, and share of patents and publications. *See* Quantifying the Competition: Assessing Leadership in Quantum Technologies, Special Competitive Studies Project (2026).

Barriers to Achieving Quantum Primacy

Several obstacles stand in the way of achieving U.S. quantum primacy. These challenges cut across all quantum technologies and span every stage of development, from foundational research to widespread adoption.

- **Building a Robust and Resilient Quantum Industrial Base.** While a strong foundational science ecosystem is key to achieving quantum primacy, the U.S. must also invest in building the physical infrastructure and industrial base to develop and manufacture quantum technologies at scale. Sustaining leadership requires factories, foundries, and suppliers to turn future breakthroughs into reliable systems. A lack of reliable manufacturing capacity for specialized components and cryogenic and photonic supply chains capable of producing quantum hardware at volume could create bottlenecks and stall deployment.

- **Securing Software Dominance.** Hardware alone will not win this race. While infrastructure makes quantum systems possible, the information layer makes quantum systems useful. Across quantum computing, sensing, and networking, this requires the software, algorithms, and control systems necessary to translate quantum capabilities into practical applications. Quantum sensing and networking depend on specialized software, protocols, and information processing capabilities to enable their effective operation, integration, and deployment. For quantum computing specifically, this includes algorithms and control systems tailored to different computing modalities, supported by error-correction protocols; algorithms that enable quantum computers to address defined applications; and cybersecurity measures that protect quantum systems. Algorithm development, in particular, remains an underfunded area in the United States, underscoring the need for continued investment in applications with the potential to demonstrate quantum advantage.[21] America must create the software that turns raw quantum processors and networks into tools that deliver real advantage. We must also shield those tools, and the classical systems they touch, from exploitation.

- **Defining Applications.** Quantum must be integrated strategically. Quantum will augment classical computing and networking, and the nations that win this competition will be the ones that integrate quantum capability most effectively into the military, industrial, and civilian infrastructure that already runs the country. Near-term quantum sensing deployments can generate practical lessons in testing, procurement, and integration. Integration and adoption, not invention alone, is where quantum primacy is ultimately won.

- **Cultivating Talent.** These efforts will depend on a strong talent backbone. A quantum-literate and capable workforce will underpin every facet of the quantum ecosystem.[22] Today, talent is a

[21] Beyond the Breakthroughs: Who will Capture Quantum's Lasting Value?, Novo Holdings (2026); Understanding Quantum Computing's Most Troubling Problem, Los Alamos National Laboratory (2025)

[22] Quantum literacy is defined as the foundational knowledge of quantum mechanics needed to understand how quantum technologies can be applied across diverse domains and to critically assess claims about their capabilities and applications. This definition builds on Nita et al.'s framing of quantum literacy in the context of quantum computation, broadening its scope to encompass quantum computing, sensing, and networking. *See* Laurentiu Nita, et al., The Challenge and Opportunities of Quantum Literacy for Future Education and Transdisciplinary Problem-Solving, Research in Science & Technological Education (2023).

binding constraint, with quantum industry, academia, and national laboratories often competing for people from the same limited pool. The near-term technical problems that need to be resolved require advanced science and engineering. Scientists are developing today's early quantum systems. Quantum engineers and technicians will build quantum technologies at scale, and quantum-educated professionals will be needed to enable widespread adoption. Workforce development must therefore extend beyond Ph.D.-level quantum theoretical and experimental scientists to include undergraduates, graduate students, technicians, educators, and applied roles. Experts from adjacent technical domains should be targeted to bring transferable skills to the solution space. A broad, well-developed workforce is needed to translate research breakthroughs into systems that can be designed, manufactured, deployed, and operated at scale.

- **Clarifying Federal Direction.** At the same time, quantum technology is still nascent, with many uncertainties. As a result, any deliberate, coordinated bipartisan national quantum effort must remain flexible and be positioned to expand and adapt as the field progresses. Legislation, dependable funding mechanisms, and coordinated cross-agency strategies should take a longer-term view to ensure leadership beyond a single administration.

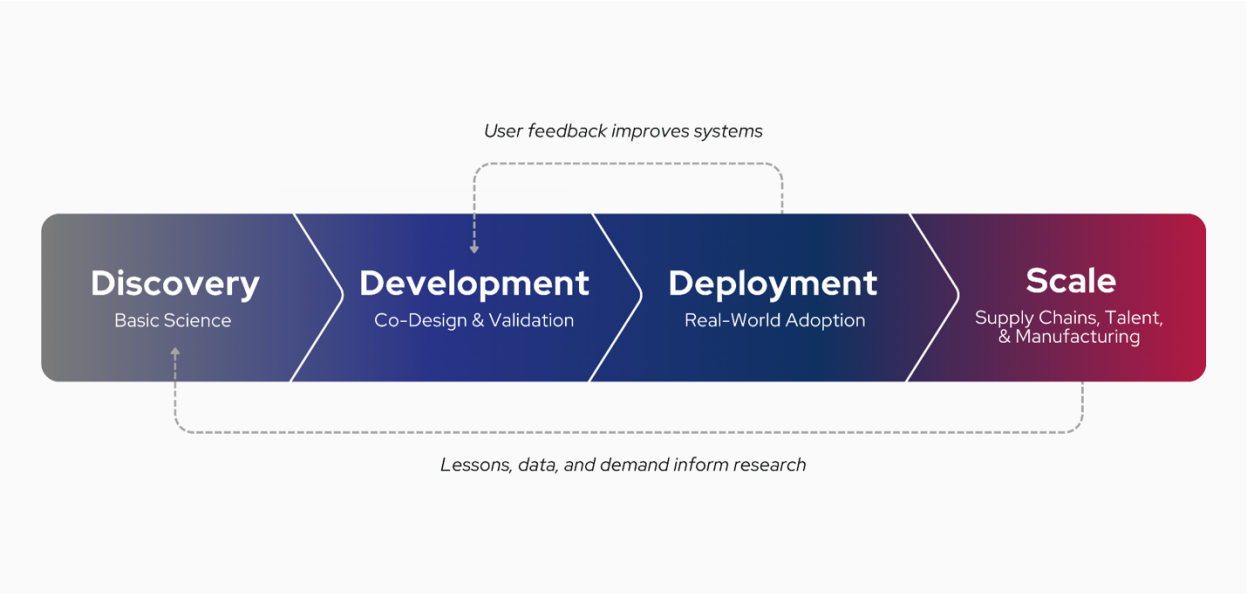
America should aim to become the place where consequential quantum capabilities are discovered, engineered, manufactured, and put to work. Success is deploying quantum sensors across multiple sectors, ranging from healthcare and agriculture to metrology and navigation; making useful quantum computers accessible to researchers and firms as quantum computing capabilities continue to mature; critical digital systems remaining secure against quantum-enabled threats; and industry continuing to invent and apply new quantum capabilities. Achieving this vision will require a robust quantum ecosystem in which national laboratories work alongside academic institutions and industry to advance quantum capabilities and build the infrastructure necessary to support their development and deployment. It would also mean American firms and trusted partners supplying the components, software, and expertise through which these capabilities reach global markets. The United States must therefore pursue leadership in the four elements that pave the way to quantum primacy.

The Four Elements of U.S. Quantum Primacy

Achieving quantum primacy requires the United States to take action across four mutually reinforcing elements at once: discovery, development, deployment, and scale.[23] Discovery generates the scientific breakthroughs that push the frontier, and development turns those breakthroughs into reliable, engineered systems. Deployment puts those systems to work in real-world settings where they create actual advantages for the United States, and scaling produces them at the volume, cost, and speed that markets and security demands require. Leading in just one element is not enough; strength across all four turns scientific progress into sustained national power and economic competitiveness.

The Four Elements of U.S. Quantum Primacy

Mutually reinforcing capabilities turn scientific progress into national strength



1. Discovery

America's quantum strength rests on decades of foundational research, sustained public investment, and institutions capable of pursuing difficult scientific questions with unforeseen potential applications. This strength has been built by America's outstanding research universities, national laboratories, and vibrant industries. Continuing to advance foundational research in quantum remains important for a thriving and innovative quantum ecosystem, as scientific leadership provides the foundation for national quantum primacy.

[23] These four elements of discovery, development, deployment, and scale can be loosely mapped to Technology Readiness Levels (TRLs), illustrating the progression of quantum technologies from scientific discovery to the development and widespread deployment of practical systems. *See* Catherine G. Manning, Technology Readiness Levels, National Aeronautics and Space Administration (2023).

The benefits of sustaining basic research are visible in the diversity of quantum technologies emerging today: all of the major quantum computing architectures being currently pursued are built on decades of foundational research, much of it supported by U.S. Government funding. Government funding can also sustain research in materials, devices, and protocols essential to useful quantum computing, sensing, and networking, particularly where national security and other public needs do not offer sufficient commercial incentives for industry investment. For example, different quantum computing architectures may offer distinct advantages for particular applications, creating value regardless of which reaches fault tolerance first.[24] Overcoming these scientific barriers forms an iterative foundational science feedback loop that builds upon itself and funnels advancements back into the broader basic science enterprise. This research enterprise also trains much of the quantum Ph.D. talent pool, cultivating expertise that supports technology development, engineering, and scale-up across this research-intensive field. Keeping this feedback loop running requires predictable and continued funding. Federal support can shift between administrations, while fundamental questions in quantum science may take years to resolve and may not align with a near-term market.

Quantum networking illustrates why sustained investment in basic science matters. It is the least mature of the major quantum technologies, with fundamental questions still unresolved across quantum memories, interfaces, photonics, entanglement distribution, and networking protocols. Yet the potential applications extend well beyond communications: quantum networks could enable distributed quantum computing, connect quantum sensors across distances, and support new approaches to secure communications.[25] Because the path to useful quantum networking—and the applications it ultimately enables—remains uncertain, sustained research across multiple approaches will be essential. More broadly, maintaining a strong basic science foundation ensures that the United States is positioned to recognize, develop, and capitalize on new quantum capabilities as they emerge.

Desired End State

- A continuously renewed scientific frontier, supported by predictable funding and the freedom to explore multiple facets of quantum science without making premature certainty about commercial outcomes a prerequisite for funding.

Near-Term Priorities

1) **Match federal ambitions with sustained investment in foundational research across the quantum field.** To pair quantum's designation as a national priority with funding that matches the scale and urgency of that commitment, increase long-term support for quantum science at federal research agencies, universities, and national laboratories, including quantum materials, devices, and computer architectures, networks, sensing, and protocols whose applications are not

[24] Mohib Ur Rehman, Types of Quantum Computers: 6 Major Quantum Computing Approaches, Quantum Insider (2026).
[25] Constanza M. Vidal Bustamante & Morgan Peirce, The Entanglement Edge: U.S. Strategic Priorities in Quantum Networking, Center for a New American Security (2026).

yet clear.[26] Utilize new and innovative funding mechanisms and partnerships to inform research priorities, increase access to research infrastructure, and accelerate promising breakthroughs.[27]

2) **Incentivize the discovery of novel classes of algorithms and applications.** Create dedicated funding tracks that support foundational research in quantum algorithms, including those that broaden the range of quantum use cases.[28] Support new collaborations and the use of AI-enabled scientific tools across mathematics, computer science, and quantum information, with longer horizons for foundational questions. Public-private partnerships could help translate foundational algorithmic advances into practical applications, and federal funding should encourage open-source or open-access release of foundational algorithms to accelerate adoption and further innovation across the field.[29]

2. Development

Turning scientific progress into useful quantum systems requires reliable ways to assess performance and integrate technologies. Quantum hardware modalities differ in their components, control stacks, and operating conditions, making systems difficult to compare or combine. Shared benchmarks and standards will make it possible to compare approaches or achieve greater interoperability across these multiple layers. Federal efforts provide foundations for this work: DARPA's Quantum Benchmarking Initiative (QBI) evaluates paths to utility-scale quantum computing, while the Department of Energy's (DOE) Quantum Genesis initiative aims to coordinate quantum hardware, software, and scientific application development.[30] The United States should build on these programs to sustain independent evaluation and

[26] E.O. 14413, Ushering in the Next Frontier of Quantum Innovation, The White House (2026).

[27] Examples of innovative funding mechanisms and partnerships include the pooling of compute resources for the National AI Research Resource (NAIRR) Pilot, the IQT funding model, and the National Science Foundation's X-Labs initiative. *See* National Artificial Intelligence Research Resource, U.S. National Science Foundation (last accessed 2026); Mission, IQT (last accessed 2026); NSF X-Labs, U.S. National Science Foundation (last accessed 2026).

[28] Increased funding mechanisms for academic teams should support foundational algorithmic questions that fall outside conventional research programs, with the goal of discovering new mathematical primitives and algorithmic frameworks that can serve as reusable foundations for further algorithm development. Such discoveries can enable researchers to develop, refine, and combine algorithmic techniques to address a broader range of problems. For instance, Hamiltonian simulation illustrates how foundational research can yield multiple algorithmic approaches and continued improvements in efficiency and accuracy. Research on Hamiltonian simulation helped advance general frameworks, including quantum signal processing and quantum singular value transformation, that can be applied to a broader range of computational tasks. *See* John Martyn, et al., Grand Unification of Quantum Algorithms, arXiv (2021).

[29] Ryan Babbush, et al., The Grand Challenge of Quantum Applications, arXiv (2025).

[30] DARPA's Quantum Benchmarking Initiative (QBI) evaluates whether a utility-scale, fault-tolerant quantum computer can be built by 2033 by assessing industry hardware concepts. In parallel, DARPA's Heterogeneous Architectures for Quantum (HARQ) program aims to optimize quantum scalability by using specialized compilers and high-fidelity interconnects to combine diverse qubit modalities within a single system, moving past single-qubit-type designs. Complementing these government-led initiatives, Oak Ridge National Laboratory's Pathfinder project integrates an IQM Radiance quantum system into world-class high-performance computing (HPC) infrastructure to advance hybrid quantum-classical workflows. DOE's Quantum Genesis initiative further connects hardware, software, and scientific application development to deliver fault-tolerant quantum computing capabilities integrated with HPC and artificial intelligence. *See* QBI, Defense Advanced Research Projects Agency (last accessed 2026); HARQ, Defense Advanced Research Projects Agency (last accessed 2026); ORNL Deploys New IQM Quantum

address integration gaps across the quantum ecosystem. Additionally, software and algorithms have not always advanced at the pace of physical devices, creating a risk that future machines will arrive before developers have practical ways to apply them. Error correction, control systems, and classical interfaces add further engineering demands. Unless all of these layers are developed with equal prioritization, advances in qubit quality or scale may remain impressive demonstrations rather than deployable, useful, and secure capabilities for researchers and end users.

Desired End States

- Hardware, algorithms, and software that are advanced through sustained co-design, so programs and applications are ready as quantum machines mature.
- Shared benchmarks, interoperable interfaces, and common components and control architectures that let researchers and developers compare systems, build across hardware approaches, and connect quantum capabilities to classical infrastructure.

Near-Term Priorities

1) **Co-develop quantum software and application ecosystems alongside hardware.** Establish a national program to fund iterative quantum software and algorithm development, potentially modeled on the Exascale Computing Project, to help ensure that future quantum application readiness continues to develop simultaneously with the delivery of hardware systems.[31]
2) **Support the build-out of interoperable systems, common control architectures and interfaces, and shared benchmarks at a national level.** Expand upon existing federal benchmarking, characterization, and validation initiatives to create a national quantum benchmarking and interoperability effort through a public-private partnership led by the National Institute of Standards and Technology (NIST) in collaboration with the Department of Energy (DOE), Department of War (DoW), and industry to consolidate existing standards and validate compatibility across hardware approaches and integration with classical computing infrastructure and software.

3. Deployment

Deployment is where quantum research becomes an economic and national security advantage, yet today's demonstrations too often remain isolated successes. Many quantum technology pilots remain vendor- and use-case-specific, limiting their ability to produce best practices for broader adoption. Integration is difficult because quantum systems must work with existing computing, communications, and operational infrastructure. Deployment therefore requires investment in supporting classical

Computer, Oak Ridge National Laboratory (2026); Quantum Genesis, U.S. Department of Energy (last accessed 2026).

[31] The Exascale Computing Project (ECP) was a $1.8 billion initiative within the U.S. Department of Energy (DOE) to deliver the nation's first capable exascale computing ecosystem by developing supercomputing hardware, software tools, and scientific applications in parallel. Through co-design, multidisciplinary teams used application needs to inform hardware and software choices while adapting algorithms to emerging machines' capabilities and constraints. A similar effort for quantum could ensure quantum software can support broad utility as quantum systems mature. *See* Exascale Computing Project, U.S. Department of Energy (last accessed 2026).

infrastructure like cloud platforms, software tools, and data, which will help integrate quantum capabilities into practical systems—from quantum computing services accessible through familiar development tools to quantum sensors combined with conventional systems. Yet, quantum technologies are maturing at different speeds. Quantum sensing already offers nearer-term opportunities in navigation, defense, healthcare, and infrastructure: sensitive magnetic measurements can help localize seizure activity, while gravity sensors have helped monitor changes beneath volcanoes. These applications could potentially provide early examples of near-term quantum deployment at scale that could benefit the broader quantum ecosystem. For instance, a cross-sector utility assessment for areas such as energy, finance, healthcare, and telecommunications could help identify where quantum tools deliver measurable value and where further development is needed.

At the same time, the United States should prepare for a future in which quantum technologies are deployed widely across the world. That means building the institutions, standards, security practices, and infrastructure not only to adopt individual systems, but also to integrate quantum capabilities securely into the broader technological ecosystem at scale. Maintaining momentum will require anticipating how quantum capabilities will interact with classical computing, communication networks, and other critical systems. Deferring security considerations will make upgrades more costly, time-consuming, and fraught with fragility and mistakes. Therefore, adequately planning for the transition of critical systems to post-quantum cryptography (PQC) is a necessary first step, while continuing to assess security needs and adapting to evolving requirements will remain essential.

Desired End States

- Quantum technologies that deliver measurable value across government, critical infrastructure, and commercial operations through sustained adoption pathways and independent evaluation.
- A quantum-resilient digital ecosystem that uses open, international, and NIST-standardized PQC and builds in cryptographic agility to respond to security and technology developments as necessary.

Near-Term Priorities

1) **Expand mission-relevant use cases.** Work with early adopters of quantum technology, like U.S. Government entities, critical infrastructure operators, and financial institutions, to identify independent, application-specific use cases and determine where quantum tools can improve performance, cost, or resilience relative to existing alternatives. Prioritize applications that can deliver value within the known constraints of current and near-term quantum hardware, alongside those that depend on more advanced quantum systems of the future. Use shared benchmarks and real-world tests to distinguish market-ready capabilities from applications that still need development. Utilize the Department of Energy's Quantum Grand Challenges as a means to spur the build-out of commercial applications.[32]

[32] The Quantum Inflection Point: Charting a Science-First Roadmap for the Nation, U.S. Department of Energy (2026).

2) **Build repeatable integration pathways.** Expand demonstrations that produce reusable evidence, procurement lessons, and hybrid quantum-classical workflows so agencies and firms can absorb new capabilities as they mature.

3) **Accelerate PQC adoption across critical infrastructure and state and local governments through risk-based assessments, implementation guidance, testing, and targeted assistance.** Use the federal phased-migration plan as a model to help form the relevant practical migration pathways, and build in cryptographic agility so systems can adapt as new algorithms become available, parameter requirements change, and implementation best practices evolve.[33]

4. Scale

No country can sustain quantum primacy if it cannot manufacture its discoveries at scale. Quantum computing, sensing, and networking draw from a broad set of critical inputs—photonics, cryogenics, specialized materials, microfabrication, lasers, and packaging—but many supply chains have single-source suppliers, long lead times, and limited domestic capacity.[34] Demand is fragmented across hardware modalities, and firms often make components in-house.[35] While this can protect individual companies, it duplicates efforts and can slow the emergence of a broader industrial quantum ecosystem.

However, supply is only part of the scaling challenge. Scaling also depends on people and partners. The quantum workforce is currently concentrated at the Ph.D. and technician ends of the spectrum, leaving fewer clear routes into the middle engineering, integration, and operations roles for people with other qualifications.[36] Companies need talent with hands-on experience before markets reach maturity, yet internships and work-based learning for professions in quantum remain limited. International talent and allied partners are also central to U.S. quantum research and industrial strength. Complementing domestic efforts, enduring policies that help to attract and retain international talent and strengthen international partnerships will be essential.

[33] IR 8547, Transition to Post-Quantum Cryptography Standards, NIST (2026); Execution of the Migration to Post-Quantum Cryptography, Office of Management and Budget (2026).
[34] Marin Ivezic, Quantum Supply Chain Risk: A Build Guide, PostQuantum (2026); Constanza M. Vidal Bustamante & John Burke, Quantum's Industrial Moment: Strengthening U.S. Quantum Supply Chains for Scalable Advantage, Center for a New American Security (2026).
[35] Constanza M. Vidal Bustamante, Atomic Advantage: Accelerating U.S. Quantum Sensing for Next-Generation Positioning, Navigation, and Timing, Center for a New American Security (2025); Constanza M. Vidal Bustamante & John Burke, Quantum's Industrial Moment: Strengthening U.S. Quantum Supply Chains for Scalable Advantage, Center for a New American Security (2026).
[36] One challenge is that as quantum technologies mature, workforce needs will expand to include more technical roles between doctoral research and routine operations. However, competition for a limited pool of Ph.D. talent also warrants attention, although total demand for these specialists is expected to remain relatively modest in the near-term. *See* Shams El-Adawy, et al., Profiles of Roles in the Quantum Industry, University of Colorado Boulder (2026).

Desired End States

- Secure quantum supply chains and a resilient quantum industrial base that provide trusted access to critical inputs and translational fabrication, packaging, integration, and testing capabilities that can pivot as technologies mature.

- Research institutions, industry, and regional training programs create experiential pathways—from vocational credentials through advanced degrees—that equip workers with transferable skills for quantum and other enabling emerging technologies, align with employer demand, support continuous learning as these fields evolve, and attract and retain international talent.

- A quantum network of trusted allies and partners that jointly develops, tests, and adopts quantum capabilities through stable market access and appropriately tailored technology-sharing rules.

Near-Term Priorities

1) **Secure supply chains and expand shared manufacturing and testing capacity.** Identify critical component dependencies, including those shared with semiconductor and AI supply chains, then expand domestic production or trusted allied supply where shortages, supplier concentration, or long lead times constrain progress.[37] Use targeted authorities such as the Defense Production Act Title III for critical bottlenecks, and establish a National Quantum Foundry Access Program for shared fabrication, metrology, packaging, pilot production, and testing across hardware modalities.[38]

2) **Build the full quantum workforce.** Leveraging the strengths of regional quantum innovation ecosystems, expand traditional academic courses, university-industry capstones, apprenticeships, and regional training programs where needed that create hands-on pathways for educators, researchers, engineers, software developers, technicians, and operators.[39] Determine or develop pathways for attracting and retaining international students and skilled workers who will contribute to U.S. quantum research and industry.

3) **Forge an allied quantum market.** Pursue joint testing, compatible procurement requirements, trusted supplier access, and appropriate technology-sharing arrangements so U.S. and allied firms can serve a larger market and create greater global demand for quantum technologies. Use and expand upon existing partnerships such as the recent Bilateral Technology Prosperity Deals and

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[37] Current quantum supply chain dependencies include helium-3, photonic materials, cryogenic systems, specialized RF electronics, and quantum-grade packaging. *See* Quantifying the Competition: Assessing Leadership in Quantum Technologies, Special Competitive Studies Project (2026); Marin Ivezic, Quantum Supply Chain Risk: A Build Guide, PostQuantum (2026); Sam Howell, The Quest for Qubits: Assessing U.S.-China Competition in Quantum Computing, Center for a New American Security (2024).

[38] Department of Commerce Announces Letters of Intent With 9 Companies for $2 Billion to Accelerate U.S. Leadership in Quantum Computing, NIST (2026); Constanza M. Vidal Bustamante & John Burke, Quantum's Industrial Moment: Strengthening U.S. Quantum Supply Chains for Scalable Advantage, Center for a New American Security (2026).

[39] For examples of recent federal scientific talent initiatives, see U.S. Department of Energy Awards $96 Million to 67 Early Career Scientists, U.S. Department of Energy (2026); FACT SHEET: The Energy Department is Ushering in a Golden Age of American Science, U.S. Department of Energy (2026).

AUKUS Pillar 2 to test quantum sensing, positioning, navigation, and timing in joint missions.[40] Apply stable, risk-based export controls that protect sensitive capabilities and permit appropriate collaboration.

Conclusion

The United States should aim to lead throughout the quantum lifecycle: generating discoveries, engineering reliable systems, putting useful capabilities into service, and supplying them at scale. Success will require sustained scientific investment alongside the industrial capacity, workforce, security, and customer demand needed to turn advances into quantum primacy.

There is a limited window of time to shape that future. The decisions made today about research, infrastructure, talent, standards, security, supply chains, and adoption will determine not only which technologies succeed, but where they are developed, who controls the critical capabilities, and whose standards and systems define the quantum era. The United States cannot assume that excellence in basic and applied research will automatically translate into leadership in deployment, manufacturing, or markets. Nor can it afford to wait for technological certainty before building the infrastructure needed to capitalize on breakthroughs when they arrive.

That is why quantum primacy must be treated as a sustained national endeavor. The government has a critical role in creating the conditions for discovery and investment, building the infrastructure and industrial capacity that markets alone may not provide, establishing standards and security foundations, and ensuring that the benefits of quantum technologies can move from laboratories into real-world applications. Industry, academia, national laboratories, and trusted allies will each have an essential role to play. The objective should not be to simply produce world-leading quantum technologies, but to build an ecosystem capable of repeatedly turning scientific advances into capabilities that strengthen American national security, technological leadership, and economic might.

The Commission's final report will translate this framework into an implementation strategy. America's opportunity is to build a national capacity that repeatedly converts quantum discoveries into useful capabilities and gives American institutions and firms a leading role in shaping their global adoption.

[40] President Trump Signs Technology Prosperity Deal with United Kingdom, The White House (2025); Memorandum of Cooperation Regarding the Technology Prosperity Deal Between the Government of the United States of America and the Government of Japan, The White House (2025); Memorandum of Understanding Between the Government of the United States of America and the Government of the Republic of Korea regarding the U.S.-ROK Technology Prosperity Deal, The White House (2025); Memorandum of Understanding Between The Government of the United States of America and the Government of Sweden Regarding the Technology Prosperity Deal, The White House (2026); Memorandum of Understanding Between The Government of the United States of America and the Government of Finland Regarding the Technology Prosperity Deal, The White House (2026); AUKUS Pillar 2 (Advanced Capabilities): Background and Issues for Congress, Congressional Research Service (2024).